Vermicompost Tea Sprays for Controlling Disease in Cucumis sativus 'Marketmore 76'

Kate J. Myers and Noah P. Elhardt

Abstract

Vermicompost contains significant numbers of biological organisms capable of suppressing plant diseases on leaf surfaces. This study, done at ECHO in southwest Florida during the spring of 2011, was conducted to evaluate the potential of foliar-applied vermicompost teas for plant disease suppression and subsequent yield increase of cucumber (*Cucumis sativus*) seeded on 15 March. Treatments included aerated, steeped (non- aerated), vermicompost leachate (extract resulting from rainwater drainage through a worm composting bin) teas, as well as vermicompost (non-liquid material applied to the soil), and rainwater. Except for vermicompost, the treatments were sprayed biweekly (beginning the third week after the emergence of cucumber seedlings) on to the foliage of cucumber plants. Disease incidence was rated on a scale of 1 to 10 with 10 indicating 100% leaf surface showing disease symptoms. Average disease ratings on 15 May were lower ($P < 0.10$) with aerated tea (rating = 2) than rainwater (rating = 2.6), leachate (rating = 2.6) and vermicompost (rating = 2.8). Aerated tea also reduced disease ratings taken 21 May; however, disease incidence by the end of the season (31 May) was not influenced by treatment. Steeped tea, leachate and vermicompost failed to reduce disease incidence below that of rainwater. Fruit number, but not weight, was influenced ($P < 0.05$) by treatments with highest fruit number (23 fruits/plot) obtained with leachate. Fruit number with leachate was higher than with all other treatments except vermicompost (20 fruits/plot). Although results were inconclusive, in terms of disease suppression, highest fruit number with vermicompost leachate indicated that this easily-produced amendment may be beneficial to cucumber production.

Introduction

(/resources/fe58ea51-77fd-4c22-9232-cd708aba5dcc)Disease, an abnormal condition affecting an organism, is one of the major factors reducing crop yields in agriculture. Two major disease agents, bacteria and fungi, propagated themselves through spores or spore-like particles, which land on leaf surfaces and, under the right condition, germinate and infect the plant. Infected plants show retarded growth, reduced yield, and often visible symptoms such as discoloration.

These diseases are usually difficult or impossible to combat once plants are infected;

consequently, farmers must try to reduce the incidence and spread of disease. This can be done in a variety of ways. In modern conventional agricultural, chemical biocides are often employed to kill disease organisms and vectors before infection can occur. However, biocides have several disadvantages that often render useless for small, sustainable agricultural systems in the developing world. Firstly, they are often prohibitively expensive for small farmers. Secondly, many disease organisms are able to adapt to chemical biocides, rendering them ineffective in a matter of years. Thirdly, the biological fallout from applying biocides often makes them far more harmful than they are useful, especially in systems that depend heavily on the natural world for nutrient cycling, disease suppression, and other vital ecosystem services.

Recent research has shown that a host of beneficial microorganisms can be employed to fight disease agents (Lowenfels 2006). In the case of bacteria and fungi infecting leaf surfaces, cultivation of a healthy community of beneficial microorganisms on the phyllosphere has been shown to be effective in warding off disease (Ingham 2003). These beneficial microorganisms work by outcompeting the disease agents for leaf surface space and plant exudates (Ingham 2003). A number of commercial spray products employ beneficial microorganisms to suppress specific diseases (Nufarm 2011). Sprays composed of vermicompost tea have been suggested as being a low-cost alternative appropriate for small-scale farmers. Compost teas host a rich diversity of beneficial microorganisms which, when applied to leaf surfaces in sufficient concentrations, can be effective in preventing disease infection (Ingham 2003).

Our objective was to evaluate several vermicompost spray solutions (see Materials and Methods section below for complete list of treatments), varying in ease of production, for disease suppression and vegetable production.

We chose cucumber as the vegetable crop because cucurbits represent an important vegetable crop that is also quite susceptible to various plant diseases. Through this research we hoped to gain understanding of the utility of inexpensive, home-produced vermicompost teas in suppressing fungal and bacterial crop diseases.

Materials and Methods

Materials:

- Rainwater
- Finished, cured, and sifted vermicompost
- Unfinished (partially decomposed), unsifted vermicompost
- 16.1 g of *Cucumis sativus* 'Marketmore 76' seed
- Tetra whisper air pump 10-30, air stone, plastic tubing and water circulation pump Stirring stick
- 4 five-gallon buckets
- 4 spray applicators Sugar cane molasses
- General Fertilizer (8-2-8)

Methods:

Field History

The experimental field was located at ECHO in southwest Florida (17391 Durrance Rd. Ft Myers, FL 33917), behind the forage bank and market garden growout area. The field had 7 raised beds which had lain fallow with a cover crop for a number of seasons before the trial. Because of this, paddy preparation was minimal, but the field did require some weeding before planting.

Experiment design

The 40 ft x 42 ft field was divided into 25 plots (raised beds) to accommodate five treatments replicated five times. A randomized complete block design was used in which each of the five replications consisted of a block of space comprised of five plots. Within a block (treatment replication), each of the five treatments was randomly assigned to one of the five plots measuring 5.5 ft in length and 3 ft in width.

Guard rows were planted along beds to the North and South of experimental field in order to minimize edge effect. Walkways were marked between every other plot for easier management and harvesting.

Treatments

1. Brewed, aerobic tea foliar spray - This compost tea followed the “bucket bubbler” method outlined in Lowenfels Teaming With Microbes and was made using finished, sifted vermicompost (2 cups/2.5 gal). 1 tsp molasses was mixed in to feed microbes in the compost. Air pump, air stone, and circulator allowed continuous permeation of oxygen throughout the brewing process. This solution had a slightly sweet smell at the end of a 24-hr brewing process. This treatment was recommended by an expert in the field, Ingam (2003).
2. Steeped, non-brewed tea foliar spray - This spray was made using the same compost as the aerobic foliar spray, but was steeped without molasses or continuous aeration. The extract solution was stirred once daily by hand. For a simple design of a compost tea circulator, see Mickelson (2008). This solution had a neutral smell at the end of a 24-hr soaking process. We included this treatment, recognizing that the air pump and related equipment for making

brewed, aerobic tea may not be readily available in many of the countries served by ECHO network members.

3. Leachate foliar spray - This solution was prepared by soaking unfinished, unsifted vermicompost in rainwater and stirred once. This was designed to replicate the conditions that create leachate, the runoff from worm compost containers, but at compost:water ratios identical to the tea and extract. This solution had an unpleasant odor at the end of a 24-hr soaking process.
4. Rainwater (control 1) foliar spray - Control plots were sprayed with rainwater from the same rain barrel used to make tea solutions.
5. Vermicompost soil (control 2) application- 1 heaping cup of finished, sifted vermicompost was applied to each hole at planting in order to inoculate the plot with beneficial microorganisms. In addition, a 1 cup side dress was applied at the first spray date. This treatment was sprayed with rainwater on the same schedule as the other treatments. As a second control, this treatment made it possible to compare disease suppression and yields of foliar- vs. soil-incorporated applications of vermicompost.

Figure 1. Leachate, extract and aerobic teas brewing (left) and ready to be sprayed (right).

For each of the above treatments applied as a spray, we sprayed approximately 1 l/treatment (250 ml/plot) for the first two spraying events. Thereafter, once the plants were established with a large amount of biomass, we sprayed about 2.25 l/treatment (450 ml/plot).

Trial Establishment (Figure 2):

The study was conducted during the spring season of 2011. Fertilizer [8-2-8 (8%N-2%P-8%P)] was applied on 10 March at a rate of 1 pound/plot. This fertilizer rate turned out to be double the proper rate, and was applied too close to the seeds. As a result, the first seeding failed as the resulting seedlings were adversely affected by salt burn. Thus, the first application of fertilizer on 10 March was considered a pre-plant application for a re-seeding event the following week on 15 March. To prepare the field for re-seeding, the beds were raked (to evenly distribute the fertilizer), but no additional compost was added.

Figure 2. Photo indicating cucumber plants and established plots

Cucumber seeds were sown in double rows, with the two rows 18 inches apart, at a rate of three seeds per planting station. Two weeks later, they were thinned to one seedling per planting station. The resulting in-row plant spacing was 18 inches. Fresh hay mulch was added at seeding and periodically throughout the trail.

The cucumber accession planted was *Cucumis sativus* 'Marketmore 76' (08074-081a). This accession is resistant to a number of diseases which make Cucurbit production in Florida particularly difficult including cucumber mosaic virus, downy mildew, powdery mildew, and scab. This variety takes 68 days to mature and bears cylindrical fruit that has a uniform dark green color and is ideal for pickling.

Trial Management

Fertility: Following the 10 March fertilizer application, the plots were fertilized two more times (13 April and 16 May) at a rate of 0.5 pounds/plot.

Treatment application: Foliar treatments were applied biweekly once the cucumber plants had reached 3 weeks of age. All compost tea sprays were brewed (sat) for 24 hours and were then applied immediately. Time of day for each spraying event was between 4PM and 6PM.

Watering: The plants were watered every other evening with overhead irrigation in order to create ideal conditions for spore germination and infection of Downy mildew. (Pundt 2011) Drip irrigation was used during particularly dry weeks in order to water the field.

Weeding: The presence and spread of nutsedges (Cyperus sp.) and dollar weed (Hydrocotyle sp.) required regular weeding. Weeds were hand pulled primarily by volunteers in the afternoon and proved labor intensive. The final weeding of the plot was done by a large work team after weeds had grown up over the cucumber plants. Cucumbers deteriorated quickly following this weeding, likely due to sun scald from the loss of shade cover.

Data collection

Disease levels were recorded six times throughout the growing season, and were recorded as estimates of percentage of leaf area affected on typical plants in each plot, on a scale of 1 to 10 (10 being 100% disease coverage). Fruit for each plot was recorded on the same six dates beginning on 5 May 11 and ending on 31 May 2011, and fruit production for each plot weighed on the final five dates. Only fruit that were marketable sized (8 in long and less than 1.5 in in diameter) and/or those of quality for human consumption were harvested. Fruit was weighed the same day or the day after harvest. Data were subjected to analysis of variance using SPSS.

Results and Discussion

Disease ratings

Up until 26 May 2011, disease ratings were quite low (Table 1). Ratings of less than 3 indicate that less than 30% of the leaf surface area manifested symptoms of disease.

Table 1. Effect of vermicompost treatments on disease ratings. Data are averaged over five replications.

	Disease rating (1 to 10 with 10 indicating 100% coverage of leaves by disease)						
Treatment*	5/5/2011	5/10/2011	5/15/2011	5/21/2011	5/26/2011	5/31/2011	Mean
Aerobic tea	1.0	2.0	2.0 a	2.0 a	2.0	3.8	2.13
Steeped tea	0.6	2.0	2.2 ab	1.8 a	2.4	3.4	2.07
Leachate	0.6	2.4	2.6 bc	2.8 b	2.8	4.9	2.68
Vermicompost	1.1	2.0	2.8 c	2.4 ab	3.0	4.8	2.68
Rainwater	1.0	2.2	2.6 bc	2.4 ab	2.4	3.8	2.40
P value**	0.476	0.775	0.083	0.088	0.571	0.670	0.296

*With the exception of vermicompost (a solid treatment incorporated into the soil), the treatments were sprayed on to the foliage of cucumber plants.

**Means within a column are considered to be statistically similar if the corresponding P value exceeds 0.10. A P value of ≤ 0.10 indicates that the numerical difference between at least two of the means, within the corresponding column, are statistically significant. Within a column of means for which the P value wa≤s 0.10, means were separated via Duncan’s Multiple Range test indicated by one or more letters following each mean; within the column of means any two means with no letters in common are statistically different from one another.

Significant differences were found between the disease ratings of some groups at the p=0.10 confidence level for the third and fourth data collection dates. On 5 May 2011, the disease rating with aerobic tea was statistically lower than that with leachate and the two control treatments (vermicompost, and rainwater). On 15 May, however, aerobic tea had not suppressed disease incidence below that with vermicompost and rainwater. At both the 5 and 15 May rating times, disease ratings were lower with aerobic tea than vermicompost leachate. Overall, aerobic tea performed the best as far as disease suppression early in the season. By the end of the season, however, disease incidence was similar with all the treatments.

Fruit production

Vermicompost spray treatments influenced fruit number (Table 2 and Figure 3) but not fruit weight. With respect to fruit number, only total-season yield was influenced by treatments. Total-season marketable fruit number was greater with worm leachate than with rainwater, aerobic tea, and steeped tea. Leachate resulted in a similar number of fruits as vermicompost, indicating that there was no advantage in terms of yield of foliar sprays over soil application of vermicompost.

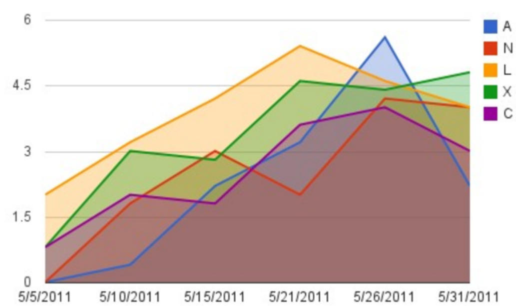

Figure 3. Effect of vermicompost treatment (A = aerated tea; N = steeped tea; L = leachate; X = vermicompost; C = rainwater) on average fruit number/plot shown in graph form.

Table 2. Effect of vermicompost treatments on cucumber fruit. Data are averaged over five replications and are shown for each harvest date as well as for the total number of fruits harvested over the entire season.							
	Fruit (number per plot)						
Treatment*	5/5/2011	5/10/2011	5/15/2011	5/21/2011	5/26/2011	5/31/2011	Mean
Aerobic tea	0.0	0.4	2.2	3.2	5.6	2.2	13.6 a
Steeped tea	0.0	1.8	3.0	2.0	4.2	4.0	15.0 a
Leachate	2.0	3.2	4.2	5.4	4.6	4.0	23.4 b
Vermicompost	0.8	3.0	2.8	4.6	4.4	4.8	20.4 ab
Rainwater	0.8	2.0	1.8	3.6	4.0	3.0	15.2 a
P value**	0.071	0.189	0.211	0.141	0.768	0.252	0.049

*With the exception of vermicompost (a solid treatment incorporated into the soil), the treatments were sprayed on to the foliage of cucumber plants.

**Means within a column are considered to be statistically similar if the corresponding P value exceeds 0.10. A P value of ≤ 0.10 indicates that the numerical difference between at least two of the means, within the corresponding column, are statistically significant. Within a column of means for which the P value wa≤s 0.10, means were separated via Duncan’s Multiple Range test indicated by one or more letters following each mean; within the column of means any two means with no letters in common are statistically different from one another.

Table 3. Effect of vermicompost treatments on cucumber fruit weight. Data are averaged over five replications and are shown for each harvest date as well as for the total weight of fruits harvested over the entire season.

	Fruit weight (grams/plot)					
Treatment*	5/10/2011	5/15/2011	5/21/2011	5/26/2011	5/31/2011	Total
Aerobic tea	57.02	350.6	629.18	1038.06	464.96	2539.82
Steeped tea	345.70	470.24	389.24	903.28	731.04	2839.50
Leachate	741.96	759.54	1220.20	930.44	973.60	4625.74
Vermicompost	591.74	524.26	1082.90	857.18	827.48	3883.56
Rainwater	411.18	297.92	776.64	819.68	634.16	2939.58
P value**	0.164	0.423	0.159	0.822	0.723	0.241

*With the exception of vermicompost (a solid treatment incorporated into the soil), the treatments were sprayed on to the foliage of cucumber plants.

**Means within a column are considered to be statistically similar if the corresponding P value exceeds 0.10. Since all P values exceeded 0.10, no mean separation test was conducted.

Summary

Our data were generally inconclusive. The aerated teas showed some benefit over the controls and worm leachate in suppressing disease for at least some of the harvest season. However, the disease suppression effect did not carry though to the end of study period. Moreover, any disease suppression did not translate to higher yields, indicating that disease pressure may not have been sufficient to be yield limiting. Concerning vermicompost tea sprays, results from this study were not convincing enough to draw firm conclusions.

Longer-term trials in this area would be useful. Future studies should include numerical data related to microbial diversity and concentrations in the tea solutions, as we feel these would be useful in helping understand experimental results.
We were surprised at the significant boost in fruit number with the leachate treatment. This result was unexpected and may deserve further study. Perhaps vegetable production can be improved with a vermicompost-derived amendment (leachate) that is easier to produce than brewed teas. It would be interesting to compare foliar-applied leachate to soil applications. Results with either method of application would likely be dependent on the ratio of rainwater to vermicompost.

Literature Cited

1. Ingham, E.R. 2003 The Compost Tea Brewing Manual Fourth Edition, Soil Foodweb Inc, Corvallis, Oregon
2. Lowenfels, Jeff and Lewis, Wayne. 2006. Teaming with Microbes. Timber Press, Portland, Oregon. p. 134-147.
3. Mikkelson, Keith, 2008. Sustainable Agriculture: A Natural Farming System.

4. Nufarm, 2011. BlightBan® A506
http://www.nufarm.com/USAg/BlightBanrA506
(http://www.nufarm.com/USAg/BlightBanrA506)
5. Pundt, Leanne, 2011. Downy Mildew. University of Connecticut.

